Do osteoarthritic subchondral bone cysts spontaneously consolidate after total hip replacement?

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Abstract: BACKGROUND During total hip replacement (THR), subchondral acetabular bone cysts are either left alone or treated by filling with autologous bone graft. We hypothesized that subchondral cysts would consolidate spontaneously over time without compromising the midterm survival of the implant. METHODS We retrospectively screened the anteroposterior hip radiographs of 731 consecutive patients who underwent primary THR between January 2006 and April 2009. Patients were included in the current study if they had acetabular subchondral bone cysts visible radiographically that had been left alone during THR. RESULTS 52 patients (54 hips) matched the inclusion criteria, with mean age of 66 ± 11 years at surgery, and a mean follow-up of 6.3 years (range 5-9 years). Among the 52 patients, there were 88 cysts, with 1.6 ± 0.83 cysts per patient and a mean cyst size of 9.3 ± 10 mm (range 0.9-57 mm). Among the 88 cysts, 71 cysts (38 hips) had disappeared by the final follow-up, whereas 17 cysts (16 hips) were still visible. Most of these persistent cysts were located in Charnley zone I and were significantly smaller at the follow-up than before surgery (p = 0.015). Overall, most cysts decreased in size (p = 0.04). All cups survived and none showed radiological signs of loosening. CONCLUSIONS After THR, most neglected subchondral cysts spontaneously consolidate or decrease in size. Larger cysts may persist without affecting the surgical outcome. No radiological signs of loosening or other adverse effects were observed when acetabular bone cysts are neglected during primary THR.

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Abstract

Background: During total hip replacement (THR), subchondral acetabular bone cysts are either left alone or treated by filling with autologous bone graft. We hypothesized that subchondral cysts would consolidate spontaneously over time without compromising the midterm survival of the implant.

Methods: We retrospectively screened the anteroposterior hip radiographs of 731 consecutive patients who underwent primary THR between January 2006 and April 2009. Patients were included in the current study if they had acetabular subchondral bone cysts visible radiographically that had been left alone during THR.

Results: 52 patients (54 hips) matched the inclusion criteria, with mean age of 66 ± 11 years at surgery, and a mean follow-up of 6.3 years (range 5–9 years). Among the 52 patients, there were 88 cysts, with 1.6 ± 0.83 cysts per patient and a mean cyst size of 9.3 ± 10 mm^2 (range 0.9–57 mm^2). Among the 88 cysts, 71 cysts (38 hips) had disappeared by the final follow-up, whereas 17 cysts (16 hips) were still visible. Most of these persistent cysts were located in Charnley zone I and were significantly smaller at the follow-up than before surgery ($p = 0.015$). Overall, most cysts decreased in size ($p = 0.04$). All cups survived and none showed radiological signs of loosening.

Conclusions: After THR, most neglected subchondral cysts spontaneously consolidate or decrease in size. Larger cysts may persist without affecting the surgical outcome. No radiological signs of loosening or other adverse effects were observed when acetabular bone cysts are neglected during primary THR.

Keywords

Acetabulum, arthroplasty, bone cysts, hip, prosthesis failure, replacement

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Background

Progressive articular cartilage loss causes changes to osteoarthritic joints that manifests in the formation of osteophytes, subchondral sclerosis, or subchondral bone cysts. Several theories exist as to the cause of cyst formation, with some authors suggesting that bone cysts develop as a result of the intrusion of joint fluid from an increase in intraarticular pressure.[1,2] Others, however, propose that destruction of the bony architecture simply provides an entry route for synovial fluid, which fills the cavities.[3] Ondrouch[4] showed that bone cyst formation is related to mechanical stress of the subchondral plate and, in a recent study, Inui et al.[5] found that a communication exists between the bone cysts of hip joints and the joint cavity in all of their 150 cases. Despite these studies, the aetiology of bone cysts is not well understood.

Bone cysts generally appear adjacent to highly degenerative joints and are often found in the weight-bearing, supra-acetabular areas of degenerated hips. During total hip replacement (THR), subchondral bone cysts on the acetabular side can be treated by filling them with autologous bone graft from the femoral head, or they are simply left

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alone. In some cases, large cysts may be critical to the primary stability of the acetabular shell when sufficient press fit is lacking. While it is important to know the location of these cysts, it is rare that treatment through curettage or augmentation is required. Indeed, since the later part of 2008, the surgeons from our department have neglected to treat acetabular cysts during the primary implantation of THR. Whether the size of these cysts decreases over time or the cysts disappear altogether remains unknown.

In this retrospective review of a consecutive case series, we tested the hypothesis that subchondral cysts consolidate spontaneously over time and do not compromise the mid-term survival times of the cup implant used during THR.

Methods

The study was approved by the Cantonal Ethical Committee Zurich: No. 2016-01366.

We identified 731 patients from the database of Balgrist University Hospital, who underwent primary THR from January 2006 to April 2009. 52 patients (54 hips) met the inclusion criteria: primary THR; radiographic identification of subchondral supraacetabular cysts; not grafted during surgery; and at least 5 years of follow-up. Hips that required acetabular edge reconstruction with autograft at the index surgery, and hips with prior surgery on the acetabular side were excluded.

In 38 hips, Quadra stems and Versafit cups (Medacta International SA, Castel San Pietro, Switzerland) were implanted; in 15 hips, a Fitmore stem and cup (Zimmer Biomet, Warsaw, IN) were implanted; and in 1 hip, an Accolade stem and Trident cup (Stryker Inc., Kalamazoo, MI) were implanted. The Fitmore cups have 2 holes, which could not be sealed during the procedure. The central holes of the Versafit (1 hole) and Trident cups (3 holes) were all sealed. Fixation screws were not used in any acetabular components. In total, we used 40 cobalt-chromium metal heads (diameter 28 mm; 9 cups in size L, 25 in size M, and 6 in size S) and 13 ceramic heads (diameter 28 mm; 2 cups in size L, 8 in size M, and 3 in size S). The polyethylene used in the Fitmore cups was a highly cross-linked polyethylene inlay (Durasul; Zimmer Biomet), that used in the Versafit was ultra-high-molecular-weight polyethylene (Highcross; Medacta International SA), and that used in the Trident was X3 highly cross-linked polyethylene (Crossfire; Stryker).

Radiographs preoperatively, postoperatively and at latest follow-up were examined by 1 author (CL), who identified all cysts according to the following criteria: well-demarcated osteolytic lesion with or without a sclerotic border. According to a study by Engh et al.,[6] measurement by several observers is not necessarily favourable, and the analysis of a series of radiographs is more accurate; therefore, we used a series of radiographs in the present study. Most cysts were not clearly visible on axial radiographs, therefore only anteroposterior radiographs were used. Cyst size was measured and documented by calculating the approximation to an elliptical area on consecutive x-rays. Consolidation of a cyst was defined as blurring of the former cyst in the absence of a sclerotic border when compared with previous radiographs, and the absence of progression in size. The location of the cysts was documented in three zones, as described by DeLee and Charnley.[7]

Statistical analysis was performed using SPSS Software (SPSS V23, IBM, Armonk, NY, USA). A Mann-Whitney U-test for independent samples was used to analyse the significance of the distribution of cyst size preoperatively. A Wilcoxon signed-rank test was used to evaluate the cyst size preoperatively and at the latest follow-up. Fisher's exact test was used to assess categorical data. Probability values less than 0.05 were considered indicative of statistical significance.

Results

The indication for total hip replacement was idiopathic osteoarthritis in all cases except for 1 patient with posttraumatic osteoarthritis, 2 patients with congenital dysplasia of the hip joint with development of secondary osteoarthritis, and 1 patient with avascular necrosis of the femoral head due to alcohol misuse.

Table 1 summarises the demographic data of the study group. On preoperative and immediate postoperative anteroposterior radiographs, 88 cysts were identified in 54 hips (52 patients). Some patients had more than 1 cyst (1.6 ± 0.83 cysts) with an initial average summated size of 9.3 ± 10 mm^2 (range 0.9–57 mm^2). Of the 88 cysts, 57 (65%) were assigned to Charnley zone I, 30 (34%) to zone II, and 1 (1%) to zone III. The mean follow-up was 6.3 years (range 5–9 years).

In 38 hips (37 patients), 71 (80.7%) cysts had disappeared by the final follow-up. Of those, 44 (62%) cysts were in Charnley zone I, 26 (37%) in zone II, and 1 (1.4%) in zone III. Figure 1 shows cystic formation of the acetabulum on preoperative x-rays and its blurry appearance immediately postoperatively and continuing until the latest follow-up.

In 16 hips (15 patients), 17 cysts (19.3%) were still visible at the final follow-up. Of these, 13 (76.5%) cysts were located in Charnley zone I, 4 (23.5%) in zone II, and none in zone III. Figure 2 shows cystic formation of the acetabulum on preoperative x-rays and its persistence postoperatively and at the latest follow-up. Of the 17 persistent cysts, 14 (12 patients) decreased in size from 19.8 ± 18 mm^2 to 13.3 ± 13.3 mm^2, and 3 cysts (3 patients) increased in size from 8.4 ± 2 mm^2 to 15.8 ± 10.9 mm^2: 1 cyst grew by 195%, 1 by 54%, and the third by 2.1%. However, we do not consider an increase by 2.1% as significant.

Table 1. Patient characteristics.

Attribute	Consolidated cysts	Persistent cysts	Progressed cysts	*p*
Average Age	67	63	64	
Gender	Male: 15 Female: 22	Male: 6 Female: 7	Male: 2 Female: 0	0.830
Number of cysts	71	15	2	
Cyst size preoperative (mm^2)	7.7 ± 6.6	19.8 ± 18	8.4 ± 2	0.015*
Cyst size postoperatively (mm^2)	N/A	13.3 ± 13.3	15.8 ± 10.9	0.004+
Charnley Zone	I: 44 II: 26 III: 1	I: 13 II: 4 III: 0	I: 2 II: 0 III: 0	0.902

Data are presented as *n* or mean ± standard deviation.
*Size of the persistent cysts was significantly smaller at final follow-up as compared with their size preoperatively.
+Cyst size of persistent cysts significantly decreased in size.

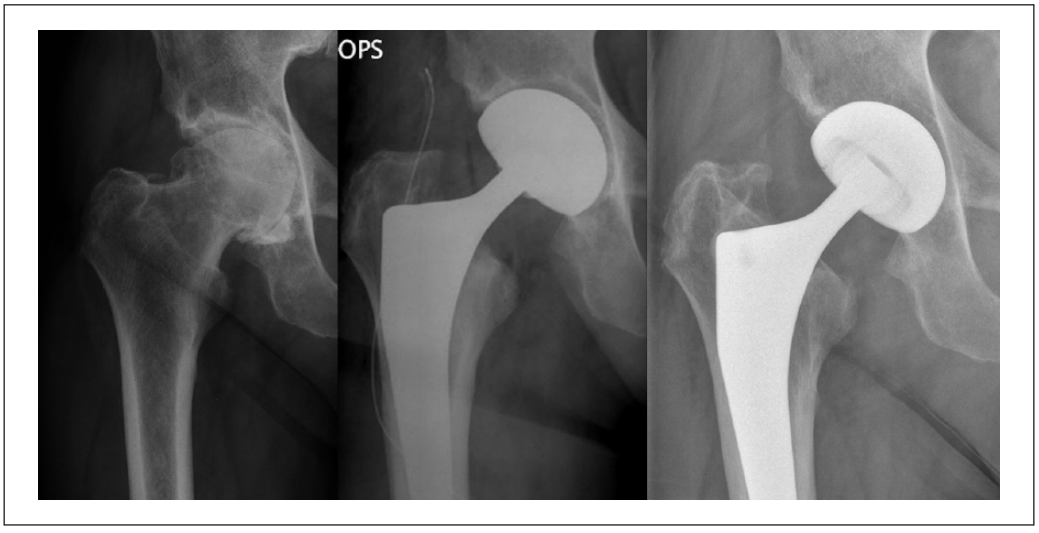

Figure 1. Cystic formation of the acetabulum on x-rays taken preoperatively and immediately postoperatively, and its blurry appearance at latest follow-up.

Because the holes of the Fitmore cups could not be sealed during the procedure, we compared the consolidation rate in patients in whom a Fitmore cup was implanted. The rate of consolidated versus persistent cysts was equivalent in these cases (23.7% vs. 25.0%, respectively).

Overall, we found that the mean size of the cysts decreased significantly ($p = 0.004$); albeit, 3 cysts increased in size. The preoperative size of the persistent cysts was significantly larger when compared with those that consolidated ($p = 0.015$). Overall, the size of the persistent cysts was significantly smaller at the final follow-up as compared with their size preoperatively ($p = 0.015$).

In terms of their positions, all of the cysts that increased over time were located in Charnley zone I. Of the 30 cysts in zone II, 26 (87%) showed consolidation, whereas 44 (77%) of the 57 cysts in zone I showed consolidation: These differences were not significant ($p = 0.902$). Similarly, we found no significant differences in terms of patient sex and cyst consolidation ($p = 0.830$): In males and females, we found that 44.3% and 55.7% of cysts had consolidated, respectively, whereas 18 cysts (9 patients) and 13 (6 patients) cysts, respectively, were still present at the final follow-up.

None of the patients showed radiological signs of cup loosening. 1 patient had an early dislocation that was successfully treated conservatively by closed reduction without recurrence. 1 patient suffered recurrent dislocation of the hip and underwent conversion to a larger head size and polyethylene (PE) exchange.

Conclusion

In this retrospective study, we examined the radiographs of 54 degenerated hip joints in 52 patients with subchondral bone cysts on the acetabular side after at least 5 years

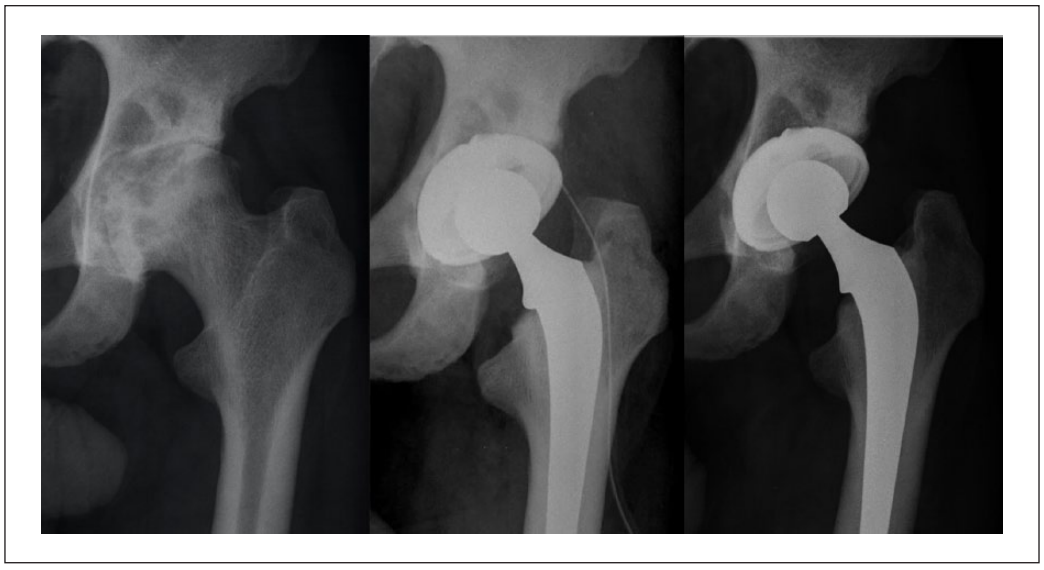

Figure 2. Cystic formation of the acetabulum on x-rays taken preoperatively and immediately postoperatively, and its persistence at the latest follow-up.

Figure 3. Lateral location of a persistent cyst of the acetabulum.

since surgery. In 81% of hips, cysts disappeared within a mean follow-up of 6 years. We found that 17 cysts were persistent, but overall, these cysts significantly decreased in size ($p = 0.004$). There were no significant differences in terms of the location of the cysts according to the Charnley zones or in the behavior of the cysts in terms of consolidation ($p = 0.902$). Likewise, the sex of the patient had no impact on cyst prevalence ($p = 0.830$), even if cysts in females did show consolidation more often than in males.

Considering the different theories surrounding the aetiology of subchondral bone cysts, it may be possible that cysts are sealed by the cup implant and that pluripotent stem cells fill these cavities and allow for the formation of new bone. However, in terms of the persistent cysts in our study, we found that 2 of these cysts increased in size (1 by 195%; the other by 54%) during the observation period. On closer inspection, we find that the cyst that increased by 54% is placed peripherally at the acetabulum, and the projection of the x-ray differs between consecutive films. Thus, we may assume that the actual size did not change over time, rather, this increase could be an artefact of the cyst being located at the lateral edge of the acetabulum (Figure 3). Furthermore, the cyst is located outside the bare area, meaning that it unlikely has a mechanical influence and a limited (if any) relationship to the joint; these 2 points may help to explain its unvaried appearance.

For the cyst that increased by 195%, this observed increase may also have been a result of an altered structure

Figure 4. Persistent cyst with change in formation and appearance.

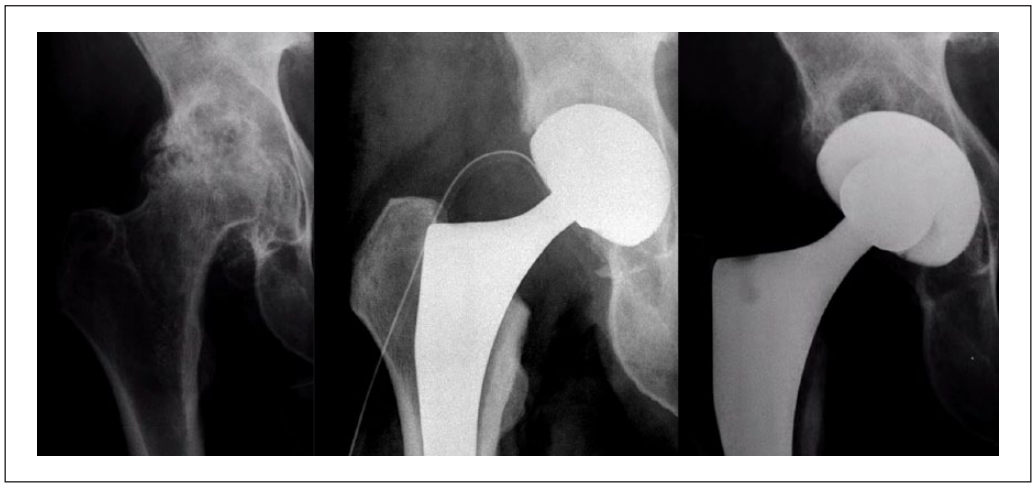

Figure 5. Multiple acetabular and femoral cysts and their change at the latest follow-up.

rather than an increase in size. On the x-ray before THR surgery, the acetabulum in this patient appeared to have 3 cysts located in the same region, with 3 different borders discernable preoperatively and immediately postoperatively (Figure 4). Yet, in the latest follow-up x-ray, there appeared to be 1 solitary cyst of a larger size. It is possible that these 3 preoperative cysts fused into one that persisted after surgery. It is also possible that there is remodelling and slow consolidation was occurring (Figure 4).

It is safe to assume that every juxtaarticular cyst is influenced by a THR implant and acetabular reaming during surgery. In most cases, this procedure leads to cyst consolidation. However, in rare cases, cysts can remodel and, over time, become more rounded and blunted before or during an ongoing consolidation. Several studies have been performed to evaluate the natural history of acetabular cysts after periacetabular osteotomy.[8,9] The authors concluded that reduction and redistribution of mechanical stress leads to regression and/or healing of subchondral femoral and acetabular cysts. In principle, THR also reduces the stress on the subchondral bone. Thus, similarities exist among the observations of the studies by Nakamura et al.,[8] Mechlenburg et al.[9], and the present study. The risk factors and patient attributes were studied and no common patterns could be found to explain the different behaviors of cysts. Figure 5 shows an example of a patient who had multiple cysts of the acetabulum and femoral head and advanced osteoarthritis of the hip. In postoperative radiographs, the supraacetabular juxtaarticular region has cleared up, with only 1 solitary, evenly rounded cyst remaining. In the case highlighted in Figure 2, the patient was treated using an

Accolade stem and Trident acetabular shell, which has several built-in screw holes for fixing the component. Thus, there would still be a connection between the joint and the cyst, and this might account for its persistence and unaltered shape. In these specific cases, again, there were no common attributes or risk factors, such as smoking, diabetes, or relevant medication. However, in patients treated with the Fitmore cups, we could not detect a higher rate of persistent cysts because the holes of the cup were not sealed. The stress redistribution and sealing effect of the implant itself probably plays a more important role than the actual sealing of the holes and possible backside wear of the acetabular cups. In the present study, cysts in zone I more often disappeared, whereas cysts in zone II more often showed consolidation. This may indicate that the consolidation process is faster in zone I. A possible explanation of this phenomenon could be less sealing effect in the periphery.

We only found 1 study, which has explored the impact of persisting subchondral cysts in THR. Kelly et al.[10] conducted a similar study in 2007 and found that cysts located in zone II were significantly more likely to progress over time than cysts located in zone I. In our study, we found comparatively higher rates of consolidation. Again, considering our theory that the implant seals the cyst and redistribution occurs, it is plausible that cysts in the middle part of the implant are more likely to be completely sealed than those found more peripherally. Kelly et al.[10] suggested that a persistent communication exists between the cysts and the hole of the dome of the acetabular component. However, we assume that the locking screw of the cup implant and the polyethylene inlay would ensure a good seal, especially in zone II, and that this would lead to eventual regression of the cyst and its consolidation. Nevertheless, as mentioned above, the sealing effect of the hole itself might be negligible. We also found the highest consolidation rate in zone II, but the differences in our study population were not significant ($p = 0.830$).

Rees et al.[11] published data on the incidence, location, and distribution of acetabular cysts. They found cysts in 82 of 100 consecutive patients; 44% had solitary cysts, which is lower than but still comparable with our results (54%).

It is worth highlighting that the radiological disappearance of a cyst does not necessarily mean consolidation and new bone formation; however, it does imply the presence of a different biomechanical influence that causes these cysts to change, regress, and/or completely diminish over time. Aside from 2 to 3 cysts, all of the cysts decreased significantly in size over time. Interestingly, the cysts that did not consolidate were also significantly larger preoperatively than those that did consolidate. Thus, cyst consolidation may simply be time dependent, with larger cysts taking longer to consolidate after THR. This may also be the case even when larger cysts are not grafted during the procedure. Overall, cysts have no impact on the risk of early loosening of the acetabular shell.

There are several limitations in this study. First, we were only able to assess cysts in one plane. As a result, we had to make assumptions in our analysis, particularly regarding the cysts that appeared to have increased in size, and we cannot pinpoint the exact location of the cysts within the supraacetabular region. Second, only 54 hips (in 52 patients) qualified for the study from a screening database of 731 patients. This was partly because most patients did not show any cysts on the initial radiograph. Additionally, however, many patients who showed cystic formation in the preoperative x-rays were lost to follow-up; this may have been due to the age of the patients, who may have found it too difficult to attend a consultation.

In summary, our findings support our initial hypothesis that cysts identified before implantation of primary THR consolidate over time and have no adverse effect on the midterm survival of the acetabular cup. Only 2 cysts showed a significant increase in size, and we suggest that these changes could have been artifacts or the result of the fusion of multiple cysts. However, if these cysts have in fact increased, they may later contribute to an osteolytic process or failure of the acetabular cup; albeit, our results showed no evidence for this, with no sign of implant loosening. These few cases should be observed and reevaluated after several more years to confirm that they do not affect the longevity of the implant. For the specific patient who showed the increase in cyst size by 195%, a follow-up of 104 months (8.6 years) was available and no adverse effects could be identified.

In conclusion, we show that cysts that do not affect the primary stability of the acetabular shell at implantation can be neglected without negatively affecting the longevity of the implant.

Declaration of conflicting interests

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